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Use of heterogeneous cover crops in olive orchards to soil erosion control and enhancement of biodiversity

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This communications presents a three year joint study, by CSIC, UCO and Syngenta, evaluating the performance of a heterogeneous cover crop, sown in the lane of an olive grove, on reducing runoff and soil losses and enhancing plant and arthropods biodiversity. This treatment has been compared, for biodiversity, with a homogeneous raygrass cover crop, and for runoff and soil losses also with tillage.
The results indicates how the heterogeneous cover crops achieved a significant reduction in soil losses, while significantly improving plant biodiversity and modifying arthropods populations compares to the homogeneous raygrass cover crop. The major limitations for expansion of this kind of cover crops are a high sensibility to water erosion during the initial sowing of the cover crop, the high cost of the seed, and the need to evaluate the risk of competition for soil water with the olives. This communication presents these results and discusses some of the alternative for expanding the use of this kind of cover crops.
Keywords: olives, erosion, biodiversity, arthropods, sustainability.

Introduction

Soil degradation, especially due to water erosion, is one of the major sustainability issues regarding olive cultivation in Southern Spain as well as in other areas of the Mediterranean (Beaufoy 2001, Fernández-Escobar et al., 20013). In the last decades it has been research on the use of soil management alternatives to tillage, such as cover crops in the area among olive tres (e.g. Gómez and Giráldez, 2009). Despite this effort in understanding the interaction among soil management, runoff, soil erosion, nutrient fluxes and biodiversity, the number of experiments is small compared to the large variability in soil and climate conditions in the Mediterranean basin. This communication presents the results of a three year long experiment in a commercial olive orchard in which a long term experiment is running since 2002, discussing the results in relation to similar experiments in olive orchards.

Material and methods

The experiment is in a commercial farm named "Santa Marta", located in the municipality of Benacazón (Seville, Southern Spain). Within this farm there is a 6 ha orchard of irrigated olive trees for table olive production. The orchards is in an area with an average slope steepness of 11%, with a sand-loamy soils classified as Petrocalcic Palexeralf. The first experimental plots were installed in this orchard in 2002. These plots were runoff plots, 60 m long and 8 m wide, and average slope of 11%. They were based on several collecting tanks connected by a runoff splitting system. They had the particularity of allowing machinery traffic within the plot using a steel-concrete shoulder on the upper boundary of the plot. During the hydrological years 2002-03 and 2003-04 two runoff plots were in operation, and since year 2004-05 the number of runoff plots has been six. Two of the runoff plots have been managed through tillage, and the remaining four plots have been managed with different combination of cover crops. A more detailed description of the study area and the experiment appears in Gómez et al. (2009). Since fall 2009 and experiment consisting of three different soil management systems has been implemented in these plots with two replications each.

The treatment called Conventional Tillage (CT) consisted in using surface tillage by a cultivator for controlling weeds in the lane among the tree lines. The number of cultivator passes was 2-3 per years and the timing depended on the weed growth. The treatment called Grass Cover Crop (GC) consisted in a cover crop in the lane among the tree lines, 4 m wide, of raygrass L. multiflorum. The cover crop was seeded in early fall 2009 and again early fall of 2010 using 80 kg ha-1 of seed (referred to the actual areas seeded) and fertilized at the time

of seeding with con Calcium ammonium nitrate 27 (13.5 de ammonium N and 13.5 de nitric N) equivalent to 40 FU of N. This cover crop was chemically controlled in using contact herbicide (glyphosate 36% brand name Touchdown Premium ®) during April, with the exact date depending on the rainfall amount during early Spring of the particular year. A central strip, approximately 1 m wide, was left unsprayed to allow self-seeding of the cover crop for the next year. The third treatment used was Mix Cover Crop (MC) seeded in the same dates that GC. It consisted in a mix of different species selected to enhance the biodiversity of vegetation as well as that of benefit fauna, arthropods, with potential for controlling some common pests in olives. The species included were: Coriandrium sat.(Umb), Borago off. (Bor), Vicia sat. (Leg), Nigella damascena (Ran), Calendula off. (Com), Echium sp (Bor), Melilotus off. (Leg), Diplotaxis sp. (Cru), Silene vulg .(Cary), Salvia verbenaca (Lam). This mix was seeded in the same dates than GC using a lower seed rate (15 kg ha-1 again rfere to the 4 m wide cover crop strip). It was mowed in, to prevent competition for soil water with the olive trees, in mid-May. In the three treatments the soil in the tree line was not tilled or seeded, and kept free of vegetation using herbicides. These herbicides have been, since 2009, oxyfluorfen and glyphosate.

The runoff and water erosion experiments performed in the plots were complemented seeding additional areas outside the plots. For the two cover crop treatments (GC, MC) an additional area of 64 x 72 m (4608 m2) was seeded per treatment. Additionally, an area of similar extension was monitored in an additional treatment called Natural Cover (NC), which refers to the spoil management made in the rest of the orchard. This management was identical to MC with the exception that no seeding was made and all the species were those naturally present in the farm. The biodiversity studies were made In these larger areas. The sampling for arthropods (combining suction and soil traps) and vegetal biodiversity were made on, April 13th 2010, May 23th 2011 and May 13th 2012. The variation in sampling dates was due to the differences in vegetation development due to different climate conditions. The mowing dates for the rest of the farm, including the NC áreas, were February, May 2010, February, June 2011 and June 2012.

Results and discussion

The three experimental years have shown a large variability in rainfall, with cumulative annual values ranging from 355 to 976 mm, in an area with a long-term average of 540 mm per year. This has resulted in a large year to year variability of annual sediment losses, which ranged from a minimum of 0.8 t ha-1 year-1 for CG treatment in year 2011-2012 to a maximum value of 71.7 t ha-1 year-1 for CT treatment on year 2009-2010. The cumulative sediment losses for the three year period were 140, 23 and 19.5 t ha-1 for the CT, MC and GC respectively, with no significant differences among the MC and GC treatments. A large year to year variability in runoff losses was also observed, ranging from 152 mm for the CT treatment in year 2009-10 to 31 mm for the MC treatment in year 2011-2012. Not significant differences were observed for the three year cumulative values in runoff for the three treatments, which were 370, 309 and 301 mm for the MC, CT, and GC treatments respectively. It is remarkable how the CT system presents unsustainable erosion rates in relatively dry years, 30 t ha-1 year-1 in year 2011-2012 with an annual rainfall of 355 mm. It is also quite clear how the cover crop treatments greatly reduced these losses with no clear differences due to the type of cover crop used. The relatively high erosion rates measured in the cover crops rates were due to a combination of severe storms during the weeks after their seeding in years 2009 and 2010. This suggests that that “window of opportunity” for water erosion within the cover crop systems should be reduced to maximize their environmental benefit. This might be achieved minimizing the periodicity of required seeding, using for instance species with a cycle better adapted to the need of control in early spring. A second management tool can be the use of some kind of direct seeding over stubble, and/or seeding only a fraction of the orchard each year if necessary. This second management option has the advantage of spreading the risk of cover crop seeding failure, a costly operation dependent upon proper rainfall during winter-spring, over different years. This experiment also indicates how differences in runoff generation among different treatments were much smaller than those measured for sediment losses, a feature already noted in similar experiments in Mediterranean conditions (Gómez et al., 2011).

The diversity of vegetation was much higher in the mix (MC) treatment compared to the grass (GC) treatment, as expected. In the GC treatment ten different species were identified in the 2012 sampling (the year of maximum diversity for this treatment) while for the same year in the MC treatment 20 species were identified. The number of species identified in the MC treatment was slightly higher than those identified in the NC treatment. It is also worth mentioning how the MC maintained a large number of the species seeded in year 2011-2012 without reseeding. For this year, 2011-2012 the GC composition had reversed to that of the NC due to the dry conditions of the year which were not suited for ryegrass.

The number and composition of arthropod in the spring sampling varied significantly among treatments. In most cases the number of individuals was higher in the heterogeneous cover crop treatments (GC and NC) compared to

the homogeneous one (GC). Within the heterogeneous cover crops treatments, the number of individuals within different classes tended to be slightly higher in MC, and one of the classes that presented that increase higher was that of predators of olive pests. This might be attributed to the increased number of species introduced in the cover crop through seeding compared to the natural vegetation of the farm which enhances the available resources (food, habitat space,. . .) of natural enemies

Conclusions

The results of this experiment suggest that heterogeneous cover cops can provide be a viable alternative as a cover crop in orchards, providing similar runoff and sediment losses compared to homogeneous grasses cover crops, and in both cases reducing significantly erosion losses compared to surface tillage. The heterogeneous cover crops provide additional agronomic and environmental benefits in terms of increased biodiversity (of plant species and arthropods) as well as a higher number of predators for pests. Among the two options, natural (NC) or seeded mix (MC) the second one performed slightly better. The reduction of the cost of the heterogeneous cover crops, compared to grasses or tillage soil management, the improvement of the seeding to achieve better and quicker implantation, and improvement in management and species composition to enlarge the number of years between seeding are some of the major lines of research to expand the use of this soil management alternative by farmers and enhancing their environmental benefits.

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